Decision Support Tools to Support Aquaculture Development in Nova Scotia
With case studies in Liverpool Bay and Main-a-dieu

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Introduction

Aquaculture has been identified as one of the most viable ways to meet the world's growing demands for steady sources of food and nutrition[1]. In 2016, global aquaculture production provided for roughly half of total seafood harvested for human consumption[9]. With 25% of the world's coastline, Canada is currently among the top 10 exporters of seafood products[2].

The Nova Scotia Department of Fisheries and Aquaculture has recognized a significant opportunity for growth of the aquaculture industry in the province[3]. In order to ensure sustainable growth which minimizes negative social, environmental, and economic impacts, site selection is a key step in the planning process[4].

Decision support tools such as modeling and suitability analysis are widely utilized to identify suitable locations for aquaculture development based on available spatial data layers[5].

Liverpool Bay and Main-a-dieu were chosen as case studies for suitability analysis in Nova Scotia since they have been identified by the province as areas of interest for aquaculture expansion.

Research Objectives

The purpose of this research was to encourage and inform sustainable growth of the Nova Scotian aquaculture industry by exploring factors which contribute to determining site suitability, with case studies in Liverpool Bay and Main-a-dieu Nova Scotia. The following objectives were considered:

- Analysis of literature to create a complete list of criteria and constraints to consider for site selection of aquaculture sites in Nova Scotia
- Creation of a geodatabase with data layers relevant to aquaculture site selection in Nova Scotia
- Production of detailed suitability analysis map outputs for shellfish aquaculture in Liverpool Bay and Main-a-dieu Nova Scotia

Methods

The research objectives were studied through a quantitative approach. The methods included document analysis to determine eligible criteria and constraints to aquaculture development in Nova Scotia, data collection of available data layers representing relevant criteria and constraints, and GIS-based suitability analysis to create suitability maps based on weighted overlay of the data.

Document Analysis: An extensive review of existing literature was undertaken to gather suitability analysis studies with similar objectives to this research. These included analysis of studies from around the world to gain a well-rounded understanding of criteria and constraint considerations. Results were compared to previously existing literature outlining suitability for aquaculture in Nova Scotia.

Data collection: Based on the data list identified through document analysis, existing data for Nova Scotia were compiled. Data were sourced through the Nova Scotia Open Data Portal, Government of Canada Open Data Portal, Nova Scotia Geographic Data Directory, Fisheries and Oceans Canada, and contacts in the Nova Scotia Department of Fisheries and Aquaculture, Nova Scotia Environment, and the Centre for Marine Applied Research. Data formats included shapefiles, geotiff images, and CSV files.

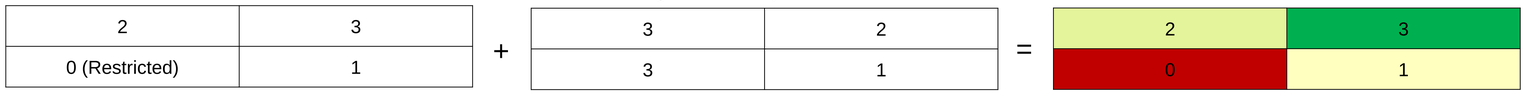
Data Formatting: In order to be included in the suitability analysis, data were converted into raster format. CSV data were converted into shapefiles using the XY Table to Point tool in ESRI's ArcGIS Pro 2.5. Point and polygon data were converted into raster surfaces using the Euclidean Distance tool[6,7]. Data with poor coverage was interpolated using spline interpolation to create full coverage raster surfaces.

Suitability Analysis in ArcGIS Pro: Using the reclassify tool in ArcGIS Pro, suitability scores were assigned to each data layer value. Layers were then combined using weighted overlay. Layers given higher weights had greater influence on the final output. Weights and suitability scores were assigned based on results of the document analysis.

Data considered for aquaculture site selection in Nova Scotia[8]

Criteria Name	Number of Datasets Identified
Physical: Biophysical Conditions & Infrastructure	
Wave Amplitude	1
Wave Period	
Water Depth	2
Temperature	2
Seasonal Weather Patterns	3
Dissolved Oxygen (DO)	1
Suspended Solids	
Water Exchange Rate (flushing)	2
Phylotoxins	
Disease Organisms	
Potential for Fouling	
Presence of Food Supply (plankton)	1
Potential of Predators	
Presence of Invasive Species	1
Presence of Naturally-Occurring Populations	
Carrying Capacity of Receiving Waters	
Heavy Metal Pollution	
Bacterial Contamination (E Coli levels)	1
Site Access	
- Roads and wharves	7
- Waste disposal	
- Generational services (fuel, food, etc.)	2
- Processing facilities	
Availability of Seed Stock/Juveniles	
Social: Other Resource Users	
Proximity to Existing Aquaculture Sites	1
Proximity to Fishing Grounds	2
Proximity to Navigational Routes	16
Proximity to Other Industry	
Proximity to Agriculture	1
Proximity to Point Sources of Sewage Effluents	2
Proximity to Tourism Operators	1
Proximity to Recreational Users	
Proximity to Residential Areas	4
Ecological: Ecologically Sensitive Areas	
Proximity to Protected Areas	2
Proximity to Informally Recognized Areas	25
Proximity to Species at Risk	1
Proximity to Important Fish Habitat	1

Weighted Overlay: How it works

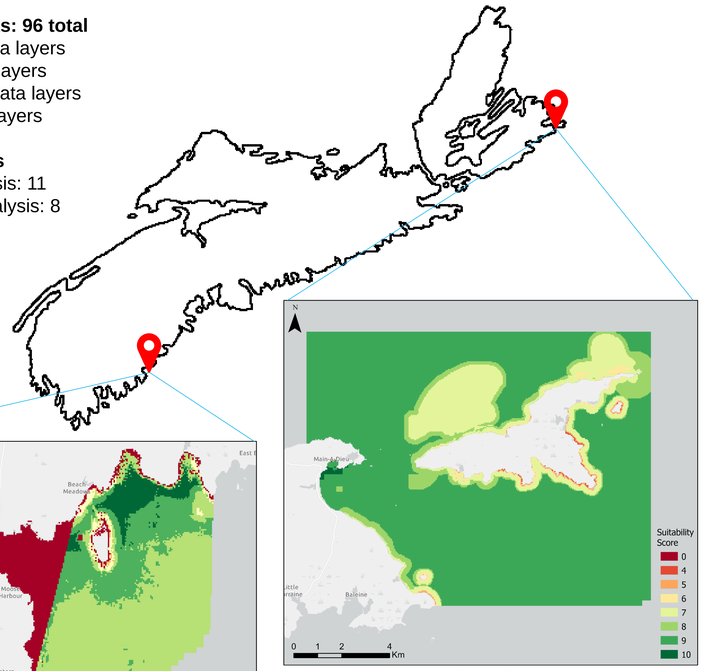


Layer 1 * 0.75 | Layer 2 * 0.25 | Final suitability. Values rounded to nearest integer

Results

Identified datasets: 96 total
- Physical: 23 data layers
- Social: 27 data layers
- Ecological: 29 data layers
- Other: 17 data layers

Included datasets
- Liverpool analysis: 11
- Main-a-dieu analysis: 8



Discussion & Conclusion

Application of these methods to future studies:
- Decision support tools such as suitability analysis can be very useful for analyzing suitable locations for aquaculture
- Suitability map outputs can identify where further efforts such as carrying capacity modelling, additional data collection, and public consultation should be focused

Limitations:
- Inability to access some important data layers
- Gaps in collected data layers
- Inability to conduct thorough public consultation, scientific review, or consideration for local knowledge to determine optimal weighting schemes and accurately represent social and economic factors

Recommendations:
- Data gaps should be addressed with emphasis on importance of sharing data publicly to open-access data portals, allowing the suitability analysis process to be repeatable
- Data collected throughout this process should be used as inputs to carrying capacity modelling and other decision support tools to further understand the impacts of aquaculture development

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